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~ ROSE DISEASES ~ THEIR CAUSES AND CONTROL



ROSE BUSHES, like all other plants, are susceptible to many diseases. Parasitic organisms may attack any portion of the plants—roots, stems, leaves, or blossoms. The presence of disease is revealed by the discoloration of the foliage, the failure of the buds to develop normally, or the death of portions of the stems. Therefore, persons who desire to grow roses, either for their beauty in the garden or for their commercial value, should have some knowledge of the causes of such diseases and the methods by which they may be prevented or controlled.

In this bulletin are described the most common fungous and bacterial diseases which may appear in the home garden, in the nursery, or in the greenhouse. The symptoms of each disease and the methods of control best adapted for general use are given.

Washington, D. C.

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ROSE DISEASES: THEIR CAUSES AND CONTROL

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INTRODUCTION

THE CONDITION known as disease in roses, as well as in other plants, is usually the result of injurious action upon the plant tissues by certain agencies. These agencies may include not only parasitic organisms which live upon the plant tissues and derive from them the food necessary for their growth, but also such conditions of light, temperature, moisture, and soil as are unfavorable for growth and which therefore inhibit the normal development of the plant. For reasons not clearly understood, certain rose plants, particularly seedlings, fail to make a good start, even though careful attention is given to growth requirements and to protection from parasitic organisms and insects. Such cases are not considered in this bulletin. Insects² may cause abnormalities of plant tissue which result in a disturbance of the normal functions. For a consideration of the insect pests of the rose, the reader is referred to Farmers' Bulletin 1495, *Insect Enemies of the Flower Garden*.

For the purposes of this bulletin, therefore, the diseases affecting the rose may be divided into two general groups: (1) Those due to conditions of growth, and (2) those due to parasitic organisms, such as fungi and bacteria.

¹ In cooperation with the Department of Botany, Brown University, Providence, R. I. Revised by Freeman Weiss, Pathologist, Division of Horticultural Crops and Diseases.

² All inquiries as to treatment for insect pests should be directed to the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, Washington, D. C.

CONDITIONS OF GROWTH

There are comparatively few localities in the United States in which some type of rose can not be grown out of doors. The tender varieties, however, such as hybrid teas, are more restricted as to favorable localities. Plants grown successfully in one locality under certain conditions of climate and soil may fail completely under the different climatic and soil conditions of another locality. Therefore, if roses are to be grown out of doors, varieties should be chosen which are adapted to the climate and the soil.³

After a suitable variety has been selected and planted, it must be provided with the proper food in the form of fertilizers; it needs water, light, and air in the right quantities. An overabundant or an insufficient amount of these factors may result in a poor root system, tender or discolored foliage, buds which fail to mature, or imperfect, weak-stemmed blossoms. In the greenhouse all these factors may be more carefully controlled, but sudden changes may cause more serious injury than in the case of out-of-door plants, which are somewhat hardened to weather changes. For this reason special attention should be given in the greenhouse to the temperature and moisture of the air and soil, the application of fertilizers, the proper ventilation, and the lighting, in order to obtain the most favorable conditions for growth, particularly during forcing.

ORGANISMS CAUSING DISEASE

The second group of diseases is caused for the most part by fungous organisms. Because of the fact that they obtain their food from the tissues of the rose plant they are called parasites. They are simple forms of plant life and reproduce by means of small bodies known as spores. One disease described in this bulletin—crown gall—is caused by a bacterium, a very simple form of plant life which, like the fungi, lives as a parasite upon the rose. It belongs to that group of organisms which cause many diseases of man.

The diseases described in this bulletin are those which appear most commonly in the home garden, in the nursery, or in the greenhouse. The methods of control recommended for each disease are those which have proved to be best adapted for general use.⁴

LEAF DISEASES

POWDERY MILDEW

Powdery mildew, caused by *Sphaerotheca pannosa* Lév. var. *rosae* Wor., is one of the most common diseases of roses and is very rarely absent from any rose garden or greenhouse during the growing season. Nearly all types of roses are susceptible, including wild roses, hybrid perpetuals, hybrid teas, and climbing roses, particularly the Crimson Rambler and Dorothy Perkins.

³ Information on the selection of varieties and methods of cultivation and pruning is given in Farmers' Bulletin 750, Roses for the Home.

⁴ Information on the use of sprays other than those mentioned in this bulletin may be obtained from the Bureau of Plant Industry, United States Department of Agriculture, Washington, D. C.

SYMPTOMS

Very early in the season, in fact soon after the leaves begin to develop, there may appear on the leaves a powdery whitish coating which is the characteristic symptom of the disease. (Fig. 1.) This coating is made up of chains of small, colorless spores, by means of which the fungus reproduces. If warm, muggy weather occurs in the late spring or early summer, the development of the disease may be extremely rapid. In the case of a severe attack the growth may become stunted, the leaves may curl, become dried, and drop off, and



FIGURE 1.—Rose leaves infected with powdery mildew

unopened buds (fig. 2), young stems, and thorns may be entirely overgrown with the powdery coating.

It is only in very rare cases that the death of the plant results from an infection by mildew. Usually the presence of the fungus only hinders the normal development of the plant and causes a disfiguring of the foliage. These, however, are sufficient reasons for attempting to control the trouble. Since the method of treatment for the pow-

dery mildew is almost identical with that for black spot, the discussion of treatment for the two diseases is combined (p. 5).

BLACK SPOT

Black spot, caused by *Diplocarpon rosae* Wolf, occurring on both outdoor and indoor roses, is almost as common as the powdery mildew. The bush roses, including teas, hybrid teas, hybrid perpetuals, and Pernetianas, are generally susceptible, though not all varieties are equally affected. On the other hand, the Wichuriana types and Rugosas are very resistant and are seldom affected.



FIGURE 2.—Powdery mildew on buds of a rambler rose

SYMPTOMS

The ordinary name of the disease is derived from the irregular black spots (fig. 3) which are the characteristic symptoms. These spots first appear as small, isolated areas scattered over the upper surface of the leaflets. As the fungus develops, these areas increase in size and may grow together until almost the entire leaflet is affected. When this condition occurs the remaining portions of the leaflet turn yellow

and it falls off. As infection spreads throughout the plant, defoliation takes place. A second crop of leaves is then developed in late summer, and this new growth does not become mature before cold weather terminates the vegetative season. As a result, the plant goes into the winter condition inadequately supplied with food reserves to resist cold and drying winds, and winterkilling is likely to occur, especially if the onset of freezing weather is early and sudden. In commercial plantings roses that are devitalized by premature defoliation are especially subject to mold and die-back during winter storage, and even if they survive till spring they make weak and sickly plants. The manner in which black spot develops differs from that in which mildew develops, in that the organism producing

black spot lives within the leaf tissue, whereas the organism producing powdery mildew lives almost entirely upon the surface of the leaf.

CONTROL OF MILDEW AND BLACK SPOT OUT OF DOORS

In the case of out-of-door roses it has been found that measures which are successful in controlling mildew are also effective against

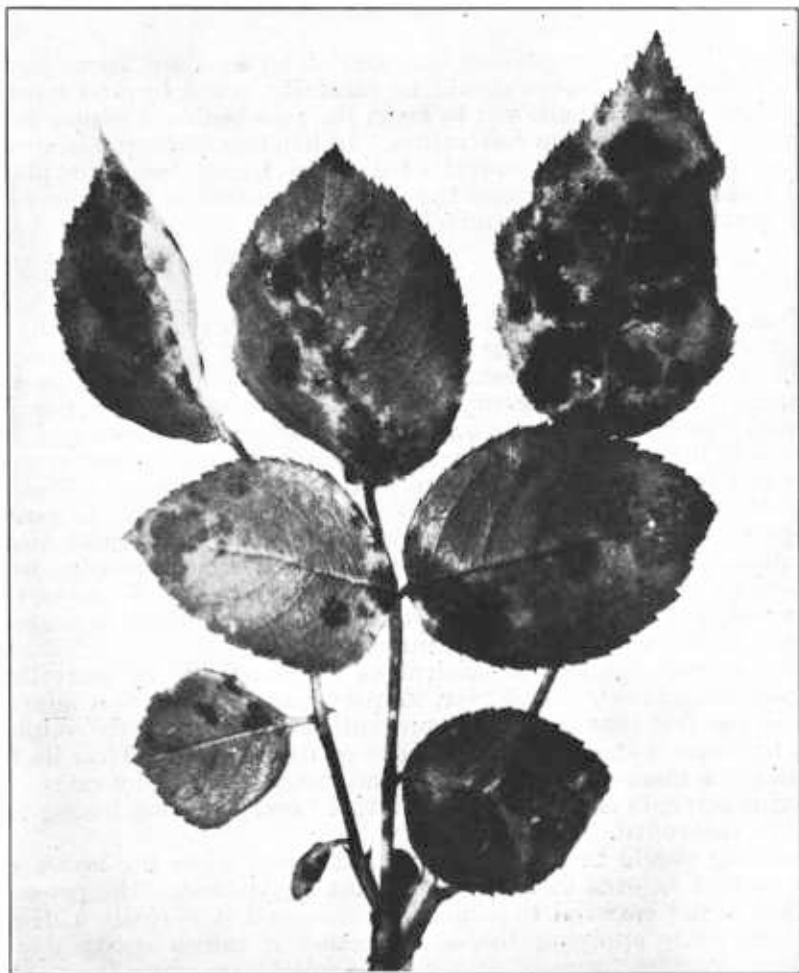


FIGURE 3.—Black spot on rose leaves

black spot. Such measures include improvement of growth conditions, sanitation, treatment with fungicides, and the growing of resistant varieties.

IMPROVEMENT OF GROWTH CONDITIONS

Germination of a fungus spore can take place only in the presence of moisture. Therefore a humid atmosphere or any other condition

in the garden which causes an accumulation of moisture on the plants is especially favorable for spore germination and the resulting infection. Such conditions may occur as a result of too-close planting, where shading and lack of ventilation prevent the proper evaporation of excess moisture from the leaf surfaces. Moreover, the planting of climbing roses near buildings has the same effect, since a free circulation of air is impossible.

SANITATION

Since the causal organisms can overwinter on dead parts of the plants, the fallen leaves should be carefully raked up and burned, and should never be allowed to lie in the rose bed over winter or be mingled with the soil in cultivation. In home gardens and in greenhouses the systematic removal of diseased leaves from the plants and from the ground reduces the sources of infection to a minimum and greatly aids disease control.

FUNGICIDES

The fungicide that has been found most practical, especially in home gardens, is a dust mixture consisting of 9 parts powdered sulphur to 1 part dry arsenate of lead. The sulphur used in this mixture is not that commonly known as flowers of sulphur, but is a specially prepared, finely ground dusting sulphur. Flowers of sulphur is of little use as a dust fungicide because of inadequate coverage by the relatively coarse particles and poor adhesiveness. Dusting sulphur is inexpensive and is obtainable from most dealers in garden supplies. It does not stain the foliage to the extent that most sprays do, though it leaves a visible coating which is sometimes considered objectionable in greenhouse and home-garden roses. To meet this objection, a form of dusting sulphur dyed green, which is scarcely visible on the foliage, has been introduced.

The arsenate of lead is efficient as an insecticide in controlling leaf-chewing insects. However, its particular value in this mixture lies in the fact that it tends to prevent the lumping of the sulphur and to increase the adhesive qualities of the mixture. Thus its use results in a more even distribution and lessens the loss by rains. If nicotine sulphate is added to the mixture ⁵ many sucking insects also may be controlled.

Dusting should be done on warm, still days when the leaves are dry, so that an even distribution of dust is obtained. The presence of dew is not essential to secure adhesion, and it is really a disadvantage while applying the dust, because it causes spotty distribution. Various forms of dusters are available, ranging from inexpensive hand dust guns to more complex devices using bellows or fans. The choice of outfit depends principally on the number of plants to be cared for, the essential thing being a device to throw a liberal cloud of dust directed from underneath so as to insure covering the lower leaf surfaces.

The first application of the dust should be made as soon as the leaves begin to develop. It is not advisable to wait until the disease

⁵ Directions for preparing and applying this dust mixture as an insecticide are given in Farmers' Bulletin 1495, *Insect Enemies of the Flower Garden*.

appears, particularly in the case of black spot, since the principal object of the dust mixture is to prevent infection. Repeated applications at intervals of 10 days or two weeks should be made until late summer, not only to make up for the loss of the powder from the leaf surfaces due to rain or other causes but also to provide protection for the new growth.

Sprays, such as homemade Bordeaux mixture or the proprietary forms of it sold at seed stores, and also commercial lime sulphur, will stain or spot rose foliage to a very objectionable degree where the leaves are needed for decorative purposes. In commercial plantings discoloration of the foliage is secondary to disease control, and spraying is preferred, at least in rainy seasons, because of the superior adhesiveness of spray coatings, which require less frequent renewal. Bordeaux mixture and ammoniacal copper carbonate, a non-staining substitute for it, depend upon their copper content for their fungicidal effect, but, although these materials are of proved value in the control of certain rose diseases, some varieties of roses are subject to a direct injury due to the copper. Therefore copper-containing sprays should not in general be used on roses except where experience indicates that a spray of this type is required for disease control; and even some of the canker diseases have recently been shown to be equally controllable, with little or no injury to the plant, by new forms of sulphur sprays.

RESISTANT VARIETIES

Different varieties of roses vary greatly in their susceptibility to mildew and black spot. Varieties which have proved resistant in one locality under certain conditions of growth may be more susceptible in another locality or under changed conditions. Therefore, rose growers who wish to control disease by growing resistant varieties should observe carefully the behavior of the plants under the conditions present in their own locality.

CONTROL OF MILDEW AND BLACK SPOT IN THE GREENHOUSE

In the greenhouse careful attention should be given to the protection of the plants from sudden changes of temperature and from drafts, so that their normal growth will not be hindered in any manner. Overwatering, especially in dark winter weather, should be avoided. Too close planting not only prevents proper ventilation but also allows infected plants to come into contact with healthy ones. In this way a spread of these diseases may easily occur.

A common method of controlling these diseases in the greenhouse is to vaporize sulphur. The flowers of sulphur is put in a vessel having a small opening and is evaporated by a low, steady heat, such as that furnished by an oil stove, until a heavy vapor fills the house. This vapor condenses on the leaves and acts as a fungicide. Great care must be taken to prevent the ignition of the sulphur, since the vapor from burning sulphur seriously injures the foliage. It is advisable, therefore, to place the vessel containing the sulphur in a larger pan of sand over the oil stove. Another method consists of painting the heating pipes during the winter with a smooth paste composed of equal parts of sulphur and lime mixed with water.

Care must be taken that sulphur is not spread on high-pressure steam pipes, where the high temperature would cause the dangerous sulphur dioxide to be given off.

RUST

The rust of roses, caused by species of *Phragmidium*, although not so common as either powdery mildew or black spot, is very destructive wherever it is found. Both wild and cultivated varieties

of roses are susceptible, but so far as known the rust does not appear on greenhouse plants.

SYMPTOMS

The most characteristic symptom of rust is the appearance, on any green portions, of small, orange-colored pustules, from the color of which the disease gets its name. In early spring there may appear on either surface of the leaves very small orange or yellow masses, usually so inconspicuous as entirely to escape detection. (Fig. 4.) Later the larger and more conspicuous spots occur on the lower surface, and this condition exists throughout the summer. In late summer or early fall the character of the spots changes and black pustules appear, frequently in the same affected areas. These pustules overwinter within the leaf tissue after the leaves have fallen, and from them are produced the spores which cause the spring infection. Other green parts of the plant, such as young stems, may also be seriously infected. Distortion of these diseased portions sometimes results.

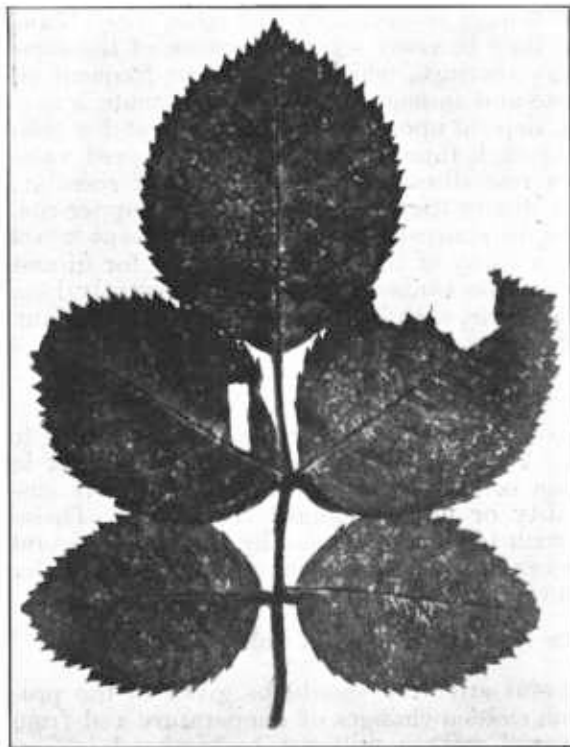


FIGURE 4.—Minute yellow spots on the upper side of a leaf, scarcely visible to the naked eye, indicate the presence of rust

CONTROL

An important step in the control of rust is to destroy the infected portions so as to prevent the spread of the infection. Therefore,

whenever possible, diseased leaves should be collected and burned at once. When the disease first appears and during the early part of the growing season the sulphur-arsenate of lead dust may be used to advantage to prevent further infection.

There is as yet no extensive experience to guide one in the choice of a fungicide to control rose rust, but in regions where the coating is not too rapidly removed by rain the sulphur dust, as described, should be as effective as any fungicidal treatment known. It must, of course, be applied at intervals frequent enough to keep the new growth covered, and care must be exercised to cover thoroughly both sides of the leaves, and especially the lower foliage. In the past Bordeaux mixture has been generally recommended for combating rose rust, but in view of its relative ineffectiveness in the control of other rust diseases there seems to be no reason for preferring it to sulphur fungicides in this case. Where a spray is required because of too rapid removal of a dust by rain, the sulphur sprays described in the section on rose cankers may at least be tried. Directions for the preparation of both types of sprays are given on page 14 of this bulletin.

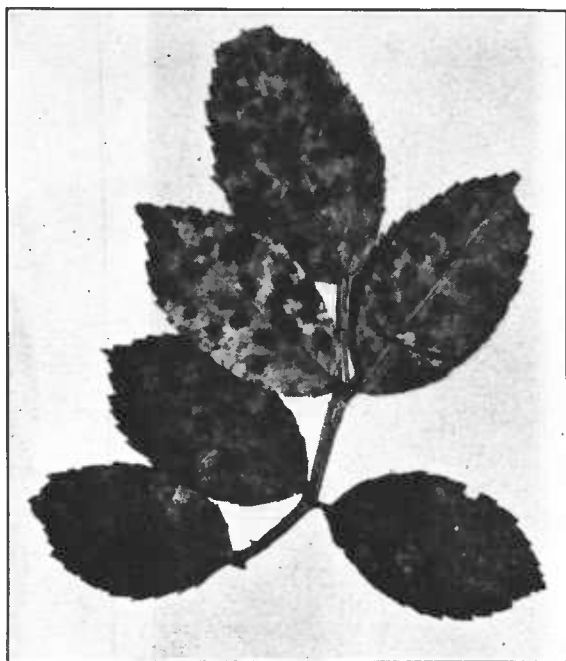


FIGURE 5.—Leaf spots as they appear on the upper side of a leaf

LEAF SPOT

Leaf spot is rarely very serious. It may occur on any variety of hybrid roses in the nursery, however, and if conditions are favorable for its development it may cause some injury to the plants through defoliation.

SYMPTOMS

Leaf spots may be caused by a number of different fungi,⁶ all of which produce the same symptoms. The spots appear first as small yellowish green dots. These increase in size, become brown, and usually have a purplish border. (Fig. 5.) In some cases the diseased tissue falls out, giving the leaves a shot-hole appearance. If

⁶Leaf spots may be caused by species of *Cercospora*, *Phyllosticta*, *Septoria*, and other genera.

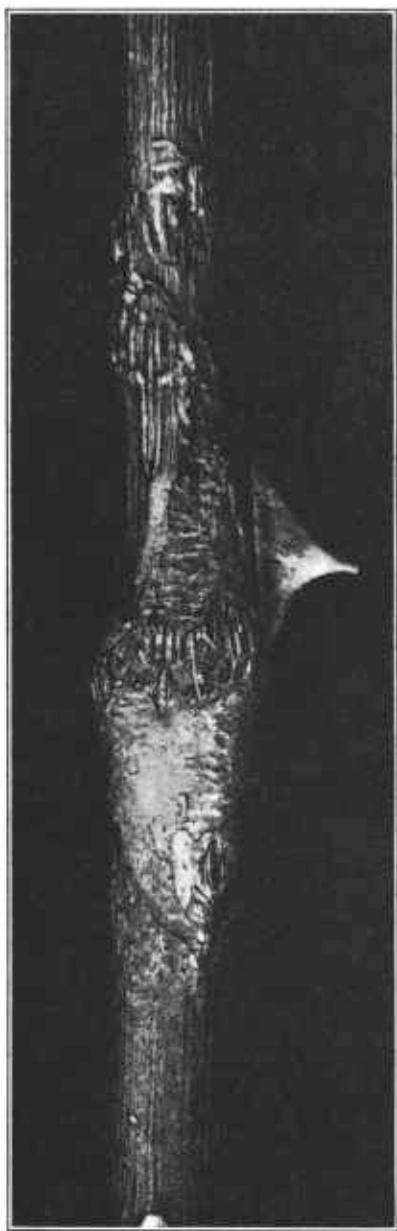


FIGURE 6.—Canker which started from infection of the wound at the lower end of the prickle. The canker extends above the wound to a point a little above the prickle and to about an equal distance below the wound. It is characterized by the smoother bark above and below the wound



FIGURE 7.—Old canker which started at the wound left by the removal of a prickle. The diseased area is slightly sunken below the surface level of the rest of the stem and is bounded by a raised margin

this diseased tissue remains as a part of the leaf, the affected areas continue to enlarge, and the whole leaf becomes yellow and falls off. The organism producing the disease continues to live on the dead tissues and bears another kind of spore which causes the spring infection.

CONTROL

As in the case of the leaf diseases already described, all affected leaves should be collected and destroyed by burning. The sulphur-arsenate of lead dust mixture recommended for mildew and black spot should be used during the growing season.

STEM DISEASES

STEM CANKER

Aside from the diseases affecting the leaves of the rose plant, one of the most important injuries which commonly occurs is the formation of cankers on the stems. Although all canker diseases are characterized by stem cankers, the diseases have been variously named by the investigators who have studied the fungi causing them. Attempts have been made to designate by a distinctive name a disease caused by a particular fungus. Therefore, although the term "stem canker" could be applied equally well to any of the diseases

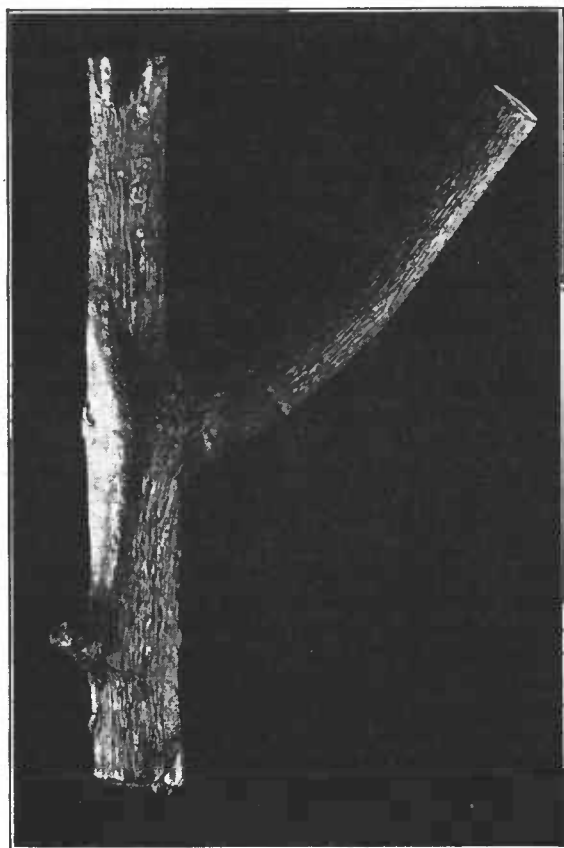


FIGURE 8.—Side view of a canker on dead stem, showing the raised margin defining the diseased area

described in the following pages, its use is commonly restricted to the disease caused by *Coniothyrium fuckelii* Sacc.

Any portion of the stem may be affected. Wounds produced in the bark from any cause whatever afford a means of entrance for fungus spores which may produce infection. (Figs. 6 and 7.) Nearly all varieties of out-of-door roses suffer from the trouble. Raspberries are also susceptible to this disease.

SYMPTOMS

The first symptoms of the disease are small pale-yellow or reddish spots on the bark. These gradually increase in size, and several spots may grow together, resulting in a large infected area. The wood tissue in these areas becomes dried and the bark cracked, so that a wound or canker is formed. (Fig. 8.) This may increase in size until the entire stem is girdled and the part above the wound becomes wilted and dies.

When hybrid tea rose plants are uncovered in the spring, very frequently it is found that the tips of the stems which have been pruned the preceding year are brown and dead. A careful examination shows the presence of a canker encircling the stem and extending down it for some distance. The lower part of an infected stem may appear healthy for some time, but if the canker is allowed to remain it slowly spreads down the stem and eventually the lower branches become infected.

Not only the larger stems but the smaller twigs, leaf and flower stalks, flower buds, and sometimes the foliage may be attacked by this canker fungus, especially if mechanical or insect injuries and spots due to other leaf or stem infecting fungi are present.

CONTROL

One of the most important measures in the control of the disease is the pruning out of all affected portions and their immediate destruction by burning. Special attention should be given to protection of the resulting cut surfaces, since it is principally through this exposed wood that infection takes place. In the spring, or just before the growing season begins, the plants should be carefully examined for the presence of cankers, and all parts thus affected should be pruned out, the cuts being made well back of the diseased tissue into the healthy wood. All cut surfaces where the wood is exposed may be covered with a coating of paint or shellac. Any wounds appearing on any portion of the stems should be similarly treated. Since spores of the fungus may easily be carried from one bush to another on the pruning shears, it is advisable in all cases where cankers are being pruned out to disinfect the shears each time after using them on a diseased plant. For this purpose a small can of kerosene, or gasoline containing a little lubricating oil, is very convenient. The excess oil should be wiped from the shears before making a new cut.

BRAND CANKER

A disease which has only recently been found to occur in the United States is that known as brand canker, caused by *Coniothyrium wernsdorffiae* Laubert. It has been reported from Minnesota, New York, Massachusetts, New Jersey, Pennsylvania, Iowa, and California.

SYMPTOMS

The cankers first appear on the bark as small, pale-brown, oval spots surrounded by a purple border. Infection seems to take place through the wounds left by the removal of prickles or through dor-

mant buds on the stems. (Fig. 9.) The spots increase in size and in some cases they completely surround the stem. The diseased bark becomes dried and cracked and the whole area is slightly sunken below the level of the healthy tissue. In many cases the woody tissue of the stem is killed only in the area defined by the purple border. The portions immediately adjoining remain green and healthy until invaded by the fungus. For this reason the cankers stand out in sharp contrast. Any portions of the canes from the ground level to the tip may be attacked, and frequently the lesions on one cane are so numerous that they coalesce. The tips of long canes of rambles may be killed back for several feet and give the general appearance of having been winterkilled. At the base of these killed portions, however, may be found one or more cankers girdling the stem.

CONTROL

All affected canes should be pruned out by cutting them back to the ground level and should be destroyed by burning. This means the complete removal of all diseased 1 and 2 year old growth. The new growth of the present season should then be sprayed as recommended for the control of brown canker.

BROWN CANKER

Brown canker, caused by *Diaporthe umbrina* Jenkins, although rather prevalent throughout the eastern and southeastern United States, has only recently begun to be recognized as one of the important fungous diseases of the rose. The disease seems to be particularly prevalent on hybrid tea roses. There is a possibility that it is present in many nurseries and rose gardens, even in propagating beds, but that because of a lack of knowledge concerning the symptoms and nature of the disease it is entirely overlooked.

SYMPTOMS

The brown cankers may occur on any portion of the stem (fig. 10) and are sometimes separated from the healthy tissue by a reddish purple border very similar to that of brand canker. They differ from the cankers already described (pp. 11, 12) principally in the shade of brown. It is this slight dif-



FIGURE 9.—Brand canker. Spores are produced in the small black pustules on the canker. The dark margin defines the upper limits of canker. Infection probably occurred through the bud shown near the center of the canker

ferentiation that causes the difficulty in distinguishing between the different types of cankers. The fungus is capable of affecting not only the stems but also the leaves and blossoms. Because of its tendency to disfigure the blossoms as well as weaken the stems, it is one of the most important rose diseases from an economic standpoint.

New infections first appear as small, slightly raised, circular, purple spots on young canes. Later these spots become grayish white, but except where several neighboring spots coalesce they remain small during the first season, developing into the large stem cankers the following spring.

CONTROL

The control of this disease is in general the same as that already described for other types of cankers. The affected portions of the stems should be pruned out and destroyed by burning. Since the foliage and blossoms may be injured by the fungus and since small cankers may escape detection, the use of a spray is advisable. Bordeaux mixture is known to be fairly effective in preventing brown-canker infection; but in view of the good control of other rose diseases, such as mildew and black spot, by sulphur preparations, much attention has recently been given to finding a single fungicidal treatment that will control the principal leaf and stem diseases, especially of garden roses. The discovery that Bordeaux mixture and other copper-containing fungicides may cause a direct injury to the canes of some varieties of roses (appearing as a purplish red spotting, accompanied sometimes by blisters and cracks) accentuates the preference for sulphur sprays so far as they afford effective disease control.

For home gardens, where the appearance of the foliage is a matter of considerable importance, the best fungicide for control of brown canker is the one already recommended for combating mildew and black spot—the sulphur-arsenate dust—but the treatment must be begun when the new canes and branches are only a few inches long and must be repeated at intervals throughout the season until frost in order to afford efficient control. It must be remembered that any spraying or dusting treatment should be combined with strict sanitary care of existing plantings and the most careful scrutiny of new plants to eliminate the sources of disease as far as possible and to avoid the introduction of new ones.

In commercial plantings the necessity for frequent renewal of the dust coatings, especially in wet seasons, is a deterrent to the use of sulphur dust, and experiments have shown that more effective disease control can be secured by spraying. A modified form of lime sulphur for summer spraying has given fairly good results, but the best records have been made by certain proprietary wettable sulphurs. These are preparations of sulphur in a very fine state of division which mix readily with water. When a spreading agent is added to the mixture, a fine, even, and very persistent coating is produced if applied with adequate pressure. Experimental work on these and other materials for the control of brown canker is still being carried on by the New Jersey and New York Agricultural Experiment Stations and the American Rose Society.

Preparation of Bordeaux mixture.—The formula for Bordeaux mixture usually employed for rose spraying is 4-5-50 or 4-6-50,

which means that 4 pounds of copper sulphate (bluestone) and 5 or 6 pounds of hydrated lime are mixed in 50 gallons of water. On a smaller scale the required proportions are 4 ounces of copper sulphate, 5 or 6 ounces of lime, and 3 gallons of water. The copper sulphate is first dissolved in about ten times its weight of water. Hot water and repeated shaking will effect a quick solution, or the chemical may be suspended in a loose-mesh bag near the top of the liquid. The lime, which must be fresh and preferably of the grade known as chemical hydrated lime, is then stirred up in one-half to two-thirds the amount of water required by the formula, and the copper-sulphate solution is diluted separately with the remaining quantity of water. The copper solution is then poured slowly into the lime solution with constant stirring. Finally a spreader should be added, which may consist of white flour, made into a smooth paste with a little water, or a commercial product. For 50 gallons of spray, 6 pounds of flour should be used, or 6 ounces for 3 gallons. Bordeaux mixture should be used immediately after its preparation.



FIGURE 10.—Brown canker. This stem was infected at three points. The portion of the stem above the uppermost canker was killed, but the leafy shoot below the lowest canker was not affected

By adding arsenate of lead to Bordeaux mixture, a spray effective against leaf-eating insects is prepared, and nicotine sulphate may be added to this or to the plain mixture for the control of sucking insects such as aphids. The usual proportions are 2 to 3 pounds of powdered arsenate of lead to 50 gallons of spray, or 2 to 3 ounces to 3 gallons; and one-half pint of 40 per cent nicotine sulphate to 50 gallons, or 1 tablespoonful to 3 gallons.

Lime sulphur.—If lime sulphur is employed, the most convenient method of preparing it is to use the commercial liquid or the powdered form in the strength recommended by the manufacturer for summer spraying. This is usually 1 gallon of the liquid or 4 pounds of the powder to 50 gallons of water, and one-half pint of the liquid or 3 level tablespoonfuls of the powder to 3 gallons of water. A flour spreader such as recommended for Bordeaux mixture is advisable.

Lead arsenate and nicotine sulphate may also be added to lime sulphur for insect control if desired.

Even this strength of lime sulphur may cause some foliage injury or growth retardation. One of the methods of reducing such injury is to add one-half pound of iron sulphate to 50 gallons of lime-sulphur-arsenate spray.

CANE BLIGHT

One of the less-prevalent diseases on out-of-door roses is cane blight, caused by *Botryosphaeria ribis* (Tode ex. Fr.) Gross. and Dug., var. *chromogena* Shear et al., which is identical with a disease of the same name occurring on currants. Although up to the present time this disease has been reported from only a few localities, it may be more common than is known, because its symptoms are identical with those produced by other causes and it may therefore be entirely overlooked.

SYMPTOMS

Usually the first indication of the presence of the disease is the wilting of the foliage. The leaves gradually become brown and dead, but remain attached for some time. This condition might easily be mistaken for injury from late frosts. However, a careful examination of the diseased stems will reveal the presence of cankers of various sizes. Sometimes the entire stem is killed from the ground level to its tip. In other cases the cankers are scattered over the stem, killing only the leaves within the affected area. Since these symptoms resemble very closely those of other canker diseases on the rose, an identification of the causal fungus is usually necessary in order to determine the particular disease.

CONTROL

The treatment for control of the disease should consist of pruning out and burning all affected portions. Because of the difficulty of thoroughly pruning out diseased areas at the ground level, very frequently portions of cankers may be left. Special care should therefore be taken to remove all cankers. The bushes may then be sprayed as recommended for the control of brown canker.

CROWN CANKER

Another type of canker (crown canker, caused by *Cylindrocladium scoparium* Morg.) affecting rose plants is caused by a fungus which is capable of living for some time within the soil and which, so far as known, attacks only greenhouse roses. It is found particularly in the eastern and northern United States.

Since infection usually occurs as a result of the growth of the fungus in the soil, the portion of the stem near the surface of the ground is most commonly affected. Any part of the stem, however, is susceptible, particularly if wounds are present. The fungus also seems to be capable of penetrating the bark tissue if wounds are not present.

SYMPTOMS

The first symptom of the disease is the appearance of small purplish spots on the bark. These areas turn reddish brown in color, increase in size, and the bark eventually becomes dry and cracked. The tips left in cutting off the flowers or in pruning back the plants may become infected in much the same way as in the case of the stem canker on out-of-door roses (p. 11). If the stem below the ground is infected, the area of infection becomes soft and rotted, and the bark can be easily sloughed off. The disease very rarely results in the death of the whole plant, but individual stems and twigs become girdled and die. The growth of the plant is seriously retarded, so that it does not respond to the usual procedure for forcing. Therefore, the usefulness of the plant as a producer of roses of commercial value is lost.

CONTROL

Because of the fact that the fungus lives in the soil, control measures differ from those recommended for the ordinary type of canker. Particular care should be taken by rose growers to prevent the spread of the disease from one greenhouse to another by infected cuttings, plants, tools, or soil. Cankers formed on the upper portions of the stems should be pruned out by cutting well back into the healthy tissue. The pruning shears should be thoroughly sterilized by being dipped in the solution of formaldehyde mentioned in the next paragraph. In order to kill the organism in the soil, it is apparent that any control measures, to be efficient, must be applied directly to the soil. This is accomplished by soil sterilization. The most efficient method in this case seems to be the use either of a solution of formaldehyde or of heat by means of steam.

In greenhouses where infected roses have been grown on benches the plants should be destroyed and the soil should be thoroughly drenched with a solution in the proportion of 1 pint of commercial formalin (40 per cent formaldehyde) to 25 gallons of water, at the rate of 2 gallons to 1 cubic foot of soil. The houses should remain closed for about 48 hours. The soil should then be turned over several times in order that it may dry thoroughly. All tools to be used on this soil should be sterilized with formalin to prevent its reinfection. After the soil has dried out and the odor of formaldehyde has disappeared the benches may be safely refilled with

roses. If the plants are potted instead of being placed directly in the benches, the potting soil should be sterilized either by formalin or by steam. This method of sterilization with formalin is not recommended for houses with ground beds, since the solution does not penetrate deeply enough to insure the complete destruction of the fungus.

Soil sterilization by means of steam⁷ is accomplished by various methods, and the decision as to which shall be employed usually depends upon the facilities at hand. Perforated steam pipes may be laid about a foot apart and then covered with soil to a depth of a foot or more. The soil may be covered with burlap bags to prevent the escape of steam into the air. It has been found by experiment that a temperature of 122° F. (50° C.) maintained for 10 minutes is sufficient to kill the fungus. Therefore, if the steam is allowed to pass through until the soil becomes completely saturated and a soil temperature of 212° F. is reached, the fungus will be killed. This temperature should be maintained for several minutes to insure the complete destruction of the fungus. Thorough sterilization is of great importance. The least particle of unsterilized soil may contain the fungus, and if this escapes the sterilization process an entirely new infection of the whole house may result.

Since the spores of the fungus may easily be carried about by particles of soil on flowerpots or tools, these also should be carefully sterilized. Boiling water, steam, or a solution of formaldehyde may be used for this purpose. If the solution of formaldehyde is used, the tools or pots are thoroughly drenched with the solution and covered for 48 hours. They are then dried and carefully protected from contaminated soil or other tools until used.

GRAFT CANKER

On grafted plants, particularly those in forcing frames, a disease caused by *Coniothyrium rosarum* Cke. and Hark., sometimes appears at or near the point of union of stock and scion. In some cases the scion only is affected, but in others both the stock and the scion are attacked.

SYMPTOMS

The presence of a canker or a callus growth at the union of the stock and scion, and the wilting of leaves are usually the first symptoms noted. The canker may entirely encircle the stem, the bark becomes cracked, and the wood tissue seems to be rotted and water-soaked. The death of the whole plant then occurs quickly. Frequently, however, the canker does not encircle the stem but spreads up it on one side. In this case the bark of the affected portion becomes brown and cracked, but the death of the plant does not immediately follow. In fact, the plant may live for several years after being transplanted to the garden, but healthy branches fail to develop on the side bearing the canker, and this results in a one-sided plant which never shows vigorous growth nor bears normal blossoms.

⁷ For detailed information on sterilizing soil by steam see Farmers' Bulletin 1320, The Production of Cucumbers in Greenhouses, and Farmers' Bulletin 1629, Steam Sterilization of Soil for Tobacco and Other Crops.

If the stock used in the graft is not resistant to the fungus, the canker may spread below the point of graft, and the death of the whole plant results. Infection of healthy plants or of new wood may take place through the cut ends left in pruning. If material for scions is taken from such infected plants, there is every chance for the spread of the infection.

CONTROL

The growing of resistant varieties only is an important factor in the control of the disease. Manetti rootstock is reported as resistant. Scion wood which has been found particularly susceptible includes the varieties Mrs. Charles Russell and Milady. Other varieties may be susceptible, although not definitely reported. Particular care should be taken to cut scion wood from disease-free plants only. In buying grafted plants rose growers should try to obtain only those with Manetti or other disease-resistant stock and with disease-free scion wood. On plants once infected the disease can not be controlled. The only measure to adopt is the destruction by burning of all infected plants.

CROWN GALL

The disease known as crown gall, caused by *Bacterium tumefaciens* Smith and Town., sometimes occurs on nursery or greenhouse roses. It affects also many other cultivated and wild plants, including peach, almond, raspberry, apple, and pear. The disease may be produced on some one of these susceptible plants such as peach or apple, and the causal organism may then be carried in soil, on pruning shears, or by some other means to a rose plant in the nursery or the home garden, where it may cause infection.

SYMPTOMS

The galls characteristic of the disease occur usually at or near the ground level, but may sometimes be found on the upper portion of the stem or on the roots. Beginning as small swellings, they increase slowly and may attain great size before any effect on the growth of the plant is noticeable. Galls produced on rapidly growing plants are commonly larger than those on more slowly growing ones. Infected plants eventually become stunted in growth, or at least fail to develop foliage and blossoms of good quality. The disease frequently develops so slowly that its injurious effect entirely escapes detection until the plant finally dies. However, cases have been observed in the greenhouse in which the spread of the disease in cuttings was so rapid that the plants were entirely destroyed during the first producing season.

The organism causing the disease is a very small bacterium which infects the plants through wounds and lives parasitically within the tissue of the plant. The cells composing the plant tissue are not killed by the organism, but are stimulated by it to abnormal multiplication resulting in the formation of the galls. The bacterium lives over winter in the diseased tissue; thus its development may easily be continued from year to year.

CONTROL

Infected nursery stock is the most common means by which the disease is spread; therefore in buying new plants particular care should be taken to procure disease-free stock, especially if the plants are grafted. Infection takes place only through wounds. For this reason the point of union of stock and scion is particularly vulnerable to infection. Grafts should be carefully wrapped and protected from injury until the union of stock and scion has healed perfectly, leaving no wound where infection might take place.

A plant once infected can not be cured. All infected plants should be removed from the garden or greenhouse and burned. Since the organism is capable of living in the soil for a year or two, roses or other susceptible plants should not be grown in infested ground for at least that length of time. If greenhouse soil has become infested it may be sterilized by the methods recommended under the discussion of the control of crown canker. In case such treatment is impracticable, the soil may be replaced by a fresh supply supposed to be free from the disease organism.

The disease may be carried from infected to healthy plants on pruning shears. Therefore all knives and shears used on diseased material should be thoroughly sterilized immediately after using by dipping in a solution of formaldehyde made in the proportions of 1 ounce of formaldehyde to 2 gallons of water. No cuttings should be made from diseased plants, since the organism may be living within the portion used.

BLOSSOM BLIGHT

One of the less common diseases is that called blossom blight, caused by a species of *Botrytis*. Very little is known as yet regarding its prevalence. It seems to affect only the undeveloped buds or half-opened blossoms.

SYMPTOMS

The characteristic symptom of the disease is the drooping of the flower buds and their failure to open. Upon examination it is found that the interior of the affected buds is filled with a cobwebby mold. There sometimes occurs also just below the flower head a smooth, slightly sunken, grayish black lesion extending down the stem. The buds appear blasted and frequently lop over at or near the lesion.

It has been found in some cases that infection of the blossoms by the fungus causing the brown canker previously described (p. 13) precedes the appearance of this blossom blight.

CONTROL

All infected blossoms should be cut and destroyed by burning as soon as they appear blasted or droop. As previously mentioned, sprays are of little value so far as the control of diseases on the buds is concerned. In order to destroy the lesions and to prevent further infection by the spores of the fungus, the stems adjoining the affected buds should be cut back some few inches below the bud. The remainder of the plant may then be sprayed with ammoniacal copper carbonate (p. 7).

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